CHAPTER 5. RESEARCH, MONITORING, AND ADAPTIVE MANAGEMENT

In order to fully implement the key strategies in this plan, determine if some of the longer-term recommendations are feasible, and learn which projects provide significant habitat and water quality benefits, a program of further research and monitoring and adaptive management is proposed. This is a critical element of the strategic approach of the plan. Without further research and monitoring, it will be difficult to determine if any of the projects have achieved their expected benefits, and additional opportunities to further protect and enhance the corridor will be missed. Additionally, we recommend the creation of a central database where data from all further research and monitoring studies can be collected and accessible to interested parties. King County may be the most appropriate agency to maintain this database.

PROPOSED ADDITIONAL STUDIES NEEDED TO FULLY IMPLEMENT THE ACTION PLAN

S-1. *Evaluate Engineered Solutions to Cool the River Upstream of Bear Creek*. This study is recommended as a programmatic action (P4), but should be designed as a study to evaluate the costs and potential effects of both hypolimnetic withdrawal from Lake Sammamish and cooling tower technology and other alternatives that may be identified during the study. Estimated cost $300K (already included as part of P4).

S-2. *Update Flood Conveyance Model*. King County and the Corps of Engineers should update the flood conveyance model based on expected conditions from implementation of this Action Plan. This should occur as soon as possible in order to allow time to correctly design of restoration alternatives to ensure there is no increase in floodwater surface elevations as a result of any of these actions. Estimated cost $100K.

S-3. *Monitor Temperature Regime in Major Tributaries and Determine if Additional Restoration Measures are Warranted to Protect and Enhance Cool Water Inputs to the Sammamish River*. Develop standard protocols for use of continuous recording thermographs and collect temperature data in several locations in Swamp, North, Little Bear, and Bear Creeks to determine if reaches are contributing to increases in water temperature. In areas of measurable heating (e.g., more than 1°C of heating) , document riparian conditions and opportunities for riparian improvements and other features that affect temperature (e.g., riprap, bulkheads, agricultural runoff, etc.). Estimated cost $100K.

S-4. *Collect Additional Temperature Data in the Lower River to Further Calibrate Temperature Model*. Recommend collecting additional data (temperature and water elevations) in Reaches 1 and 2 to better understand how stratification caused by Lake Washington backwater impacts model results. Also conduct further longitudinal temperature monitoring and dye studies to provide travel time estimates. Also, use tributary data collected for S-1, above to allow the model to more accurately predict the effects of various restoration measures on water temperature. Estimated cost $100K.

S-5. *Evaluate Groundwater Inflows at Norway Hill*. Continued development is occurring in the Norway Hill area and may reduce groundwater recharge over time due to increased impervious surface area. A study to determine if groundwater flow into the river is from shallow or deep aquifers should be conducted to determine the potential effects of increased impervious surface area and possible mitigation measures that could be enacted. Estimated cost $100K.

S-6. *Continue Groundwater Studies*. King County has already conducted some initial investigations into presence and quality of groundwater in the corridor. These studies should be continued to determine the location, volume, and water quality condition of the groundwater table, particularly in Reach 3-6.

If any groundwater sources are potentially appropriate to use for diversion into pools, a demonstration project should be implemented and monitored to determine if groundwater will provide sufficient temperature stratification in pools and create a cool-water refuge for salmon. Estimated cost $300K.

S-7. *Investigate Groundwater Recharge Opportunities*. Further research should also be conducted to determine if treated wastewater could be utilized to augment groundwater recharge, and/or opportunities to percolate stormwater runoff to augment groundwater flow, rather than only providing temporary flood storage. As part of recommendation P8, one or two small groundwater recharge wetlands should be constructed and monitored to determine rate and volume of groundwater recharge that is possible in different soil types and the concentration of any pollutants in groundwater flowing from the recharge sites. There may be restrictions on where reclaimed water can be used to recharge groundwater depending on adjacent wells and their uses. Dye testing could also be conducted to determine if groundwater then flows into the Sammamish River or adjacent tributaries. Estimated cost $500K.

S-8. *Identify Wetland Restoration and Enhancement Sites*. Several wetlands exist in Reaches 3 and 4, but are isolated from the river and have very poor habitat (reed canary grass dominated). It is recommended that an investigation of these wetlands be conducted to determine if they are suitable and feasible for reconnection to the river for seasonal inundation to promote groundwater recharge. Restoration elements could include removal of non-native vegetation; excavation of wetlands and channels; riparian and wetland revegetation with native trees, shrubs, and emergents; and placement of LWD in wetlands and river shoreline. Even if it would not be feasible to restore groundwater recharge or provide fish access, these wetlands could provide wildlife habitat. Estimated cost $50K.

S-9. *Identify and Prioritize Removal of Fish Passage Barriers*. The cities and King County have identified fish passage barriers in several tributaries to the Sammamish River, but the data has not been consistent, particularly in the determination of what constitutes a fish passage barrier. It is recommend that a comprehensive survey of the corridor be conducted to identify all fish passage barriers (adult salmonid barriers). Information should be collected on the type and magnitude of barriers and habitat conditions upstream of the barriers. In addition, develop a plan for prioritized removal of barriers based on quality and area of habitat upstream, type of fish expected to use the habitat, and other features. Estimated cost $75K.

S-10. *Review Results of King County Water Quality Study and Conduct Literature Review to Determine if a Demonstration Agricultural Infiltration Basin is Needed or Feasible to Treat Irrigation Return Flows*. Because irrigation return flows may contribute to high water temperatures and export potential contaminants into the river (Wilson, *et al* 2001), an evaluation of King County's recent toxicity data should be conducted to determine if measures to prevent direct runoff should be taken. One option is an agricultural infiltration basin/wetland demonstration project. A literature review of the effectiveness of these wetlands should be first conducted to determine if the pollutants of concern could be removed. If so, a demonstration wetland could be constructed and monitored to further determine its effectiveness for reducing temperature and other pollutants in irrigation return flows. Such a basin/wetland could be constructed at the location of an existing irrigation return flow. Features would include excavation of a wetland large enough to receive the irrigation return flow volume and hold it for a minimum of 24 hours before passive outflow over a sill or similar structure, plantings of dense emergent and shrub wetland vegetation and a riparian forest zone for shading, and removal of non-native species. The project should be designed so that it does not capture and strand fish during high flows. Estimated cost $20K for study, $100K for design of infiltration basin.

S-11. *Water Quality Study*. Some key questions remain about water quality in the river based on the 303(d) listings: the seriousness of both bacteria and turbidity/suspended sediments in the river. It is recommended that a study be conducted to further quantify bacterial concentrations throughout the river and identify potential bacteria sources, such as at Marymoor Park and urban outflows. Also

recommend collecting turbidity measurements throughout the year and particularly downstream of urban outfalls to determine frequency, concentrations, and potential sources of fine sediments. Estimated cost $100K.

Implementation of the above studies would cost approximately $1.6 million (not including S-1, which was already included in P4). These studies are very important to understand if any further actions can be undertaken to reduce temperatures in the river, ensure there are no adverse effects on flood control from any proposed restoration actions, and reduce the runoff of potential contaminants into the river.

MONITORING PLAN

Monitoring is necessary to determine if specific restoration objectives are being met for individual and programmatic projects, and if not, to implement adaptive management actions. In particular, for this Action Plan, monitoring is necessary to ensure that early projects implemented under the programmatic recommendations are providing the expected benefits, in addition to providing feedback and additional design information for later projects. To this end, we propose four types of monitoring: (1) construction monitoring; (2) success monitoring at the localized scale; (3) success monitoring at the corridor scale; and (4) monitoring of adaptive management actions. This monitoring plan is intended to be the basis for development of a more detailed monitoring program that must be prepared as the recommended projects are being designed.

Construction Monitoring

Monitoring will be required during the construction phase or phases to ensure that all water quality and other permitting requirements and/or conservation measures are met, and also to ensure the project is built according to design specifications (or if not, there is a documented technical reason for the deviation). This monitoring will occur on a site-specific basis and be funded as part of the overall project construction costs. Specific tasks would likely include turbidity and other water quality measurements (upstream and downstream of project); removal of fish species within the work area; flagging and monitoring of vegetation that will not be removed; oversight by a biologist of all construction activities; and implementation of all erosion control requirements.

Success Monitoring at the Localized Scale

Success monitoring documents whether the project is surviving (e.g., planting project) and functioning (e.g., are pools persisting over time?) as expected. At the localized scale, the growth and survival of plants and stability and persistence of features is of particular interest. At each project location, these types of monitoring efforts would be undertaken for approximately five to ten years following construction. The exact length of required monitoring would be based on the type of project.

Riparian Revegetation

For several years (typically years 1, 2, 5, and 10) after construction, the riparian vegetation plantings should be evaluated for percent cover, canopy cover over the river, and overall percent survival. Percent survival should be greater than 90% in all years. If excessive mortality occurs in year 1 (greater than 20%), additional measures may need to be taken, such as irrigation and replacement plantings. In later years, the project sponsor would be responsible for supplementing the plantings if there are unacceptable levels of mortality. Adaptive management measures may need to be taken to increase survival of plants, such as use of fencing or other measures to prevent beaver predation, planting of more suitable species for a location, etc. Irrigation of plantings should be provided at all projects for one to three years, based on existing experience with riparian plantings. Monitoring should always occur during the July -August timeframe to document the maximum growth of each season.

Stability/Persistence of Aquatic Features

Aquatic features such as shallow banks, pools, and LWD clumps/jams should be monitored to determine if they are persisting over time (e.g., maximum depth, residual depth and surface area) and if hydraulic conditions have been created that affect their function or if additional pools have been created. Cross sections or other representative points in and adjacent to specific restoration projects should be surveyed (years 1, 2, and 3 after construction) to determine if sediment deposition or erosion has occurred, and if so, the cause and magnitude. LWD should be monitored to determine if it has moved or caused any bank erosion.

Success Monitoring at the Corridor Scale

Success monitoring at the corridor scale will enable this Action Plan to be implemented as a series of experiments with adaptive management and design feedback to ensure later projects are as effective as possible. As each project is implemented, its associated effects and benefits will be monitored and compared to other projects in the corridor so that each subsequent project can be designed to function most effectively for its location. For example, because it is currently expected that juvenile salmon use the upper river more than the lower river for rearing habitat, a comparison of fish use of shallow water habitats specifically created in upper and lower reaches of the river can be conducted to determine if future projects in the lower river should include shallow water habitats. This scale of monitoring is particularly necessary to evaluate the programmatic recommendations (riparian restoration and creation of pools) and to determine if water temperature is being reduced. This monitoring program should be funded by all parties to this Action Plan on a proportionate scale to the number and size of projects undertaken by each party. Funds could be allocated as part of the construction budget of each restoration site that would be contributed to the overall program or funded separately as a monitoring program. The following types of studies should be undertaken throughout the corridor.

Adult Fish Use of Pools

Pools created in various parts of the river should be evaluated during the warmest months (July through November) to determine adult salmon use; compare fish use of created pools to existing pools and deeper areas; and evaluate pool temperature and compare tributary confluence pools to groundwater inflow pools and to other pools to determine if cool water refuges were actually created and are functioning.

Juvenile Salmon Use of Various Habitats

Several programmatic features may be used by juvenile salmon for rearing, cover, or refuge including shallow bank habitats, LWD clumps and jams, pools, and overhanging vegetation. Comparisons should be made between fish use of each of these habitat types and between different locations in the river. Additionally some sampling should be conducted in areas of aquatic vegetation (both native and non-native) to determine what fish species are utilizing these habitats. Sampling should be conducted year-round to determine if species that rear in freshwater for extended periods are utilizing these habitats.

Wildlife Use of Various Habitats

Wildlife use of riparian areas, wetlands, side channels, and in-stream locations should be monitored. Bird species counts could be conducted at various seasons (nesting, wintering, etc.) to identify how the riparian zone is improving (conduct in conjunction with Audubon Society and other groups). Particularly, use of LWD and other wildlife features (snags, etc.) should be compared to areas without those features and to different parts of the corridor.

Water Temperatures

Permanent temperature measurement stations should be established to document responses to restoration actions. It will take many years for the riparian restoration to achieve a significant level of shading, but year-

to-year variations and other restoration actions can be monitored in the interim. The following features should be monitored extensively for water temperature changes: pools, tributary confluences and mixing; effects of Lake Washington elevations on backwater conditions; groundwater inflows and mixing; cooling tower or other demonstration project; and wetlands and side channels.

Biological Health of the Aquatic System

Baseline, and then follow-up monitoring studies of invertebrate populations should be conducted. Index of Biotic Integrity (IBI) is probably not appropriate in the Sammamish River, but other indices may be used to assess the overall health of the aquatic ecosystem. Samples should be taken adjacent to various types of projects and near tributary confluences, as well as representative samples in various habitat types.

Population and Recovery Estimates

Fry trapping is currently conducted in lower Bear Creek to estimate population size of various salmon stocks in the Bear Creek sub-basin. To determine if recovery is occurring as a result of restoration actions taken in the Sammamish River Corridor and throughout the Greater Lake Washington Watershed, fry trapping and adult spawner surveys need to occur throughout the watershed. It is recommended that population studies be conducted in more detail in the Sammamish River Corridor to include other major tributaries and compare outmigration and survival in the upper versus lower river. This should be integrated with the broader WRIA 8 monitoring currently under development, which will probably be conducted by WDFW and the treaty tribes.

Adaptive Management and Additional Monitoring

The success monitoring (at both scales) must be used by parties to this Action Plan to undertake adaptive management of existing and future projects to achieve the goals of this plan. To be most effective, an Adaptive Management Team should be formed with representatives from each jurisdiction and interested resource agencies[21], with funding provided from each jurisdiction or agency. This Team will direct and implement the research and monitoring plan and determine if any adaptive management actions are necessary. Decision-making could include one or more of the following response actions:

- No Action
- Further Monitoring (continued years of same studies or propose new studies)
- Maintenance or Modification of Specific Projects or Project Features
- Design Modifications for Future Projects
- Modification of Restoration Strategies

An annual report on the monitoring results should be prepared each year by the entity(ies) conducting the work and submitted to the Adaptive Management Team. The report(s) would summarize monitoring data collected during the previous year and recommendations on any adaptive management measures (either monitoring modifications or actions to modify restoration features). The Adaptive Management Team would use the information in the report(s) to assess progress toward the restoration objectives and identify remedial actions that could be implemented to rectify problems. The Adaptive Management Team would prepare a memo documenting the results of its assessment of the mitigation program that would include recommendations for the following year's monitoring plan. An annual report on monitoring would continue

[21] A technical representative from the Cities of Kenmore, Bothell, Woodinville, and Redmond; King County; Corps of Engineers, at a minimum should be involved. This team should coordinate with a potential adaptive management team from the broader watershed and also include WDFW, tribal, NMFS and USFWS representatives. Other agencies may be involved as interested.

for an agreed upon period (5, 10, or longer period of years) until the Adaptive Management Team was satisfied with the success of the Action Plan. At this time, we recommend that the Action Team that developed this plan scope out an operating plan for the Adaptive Management Team in conjunction with the WRIA 8 technical committee.

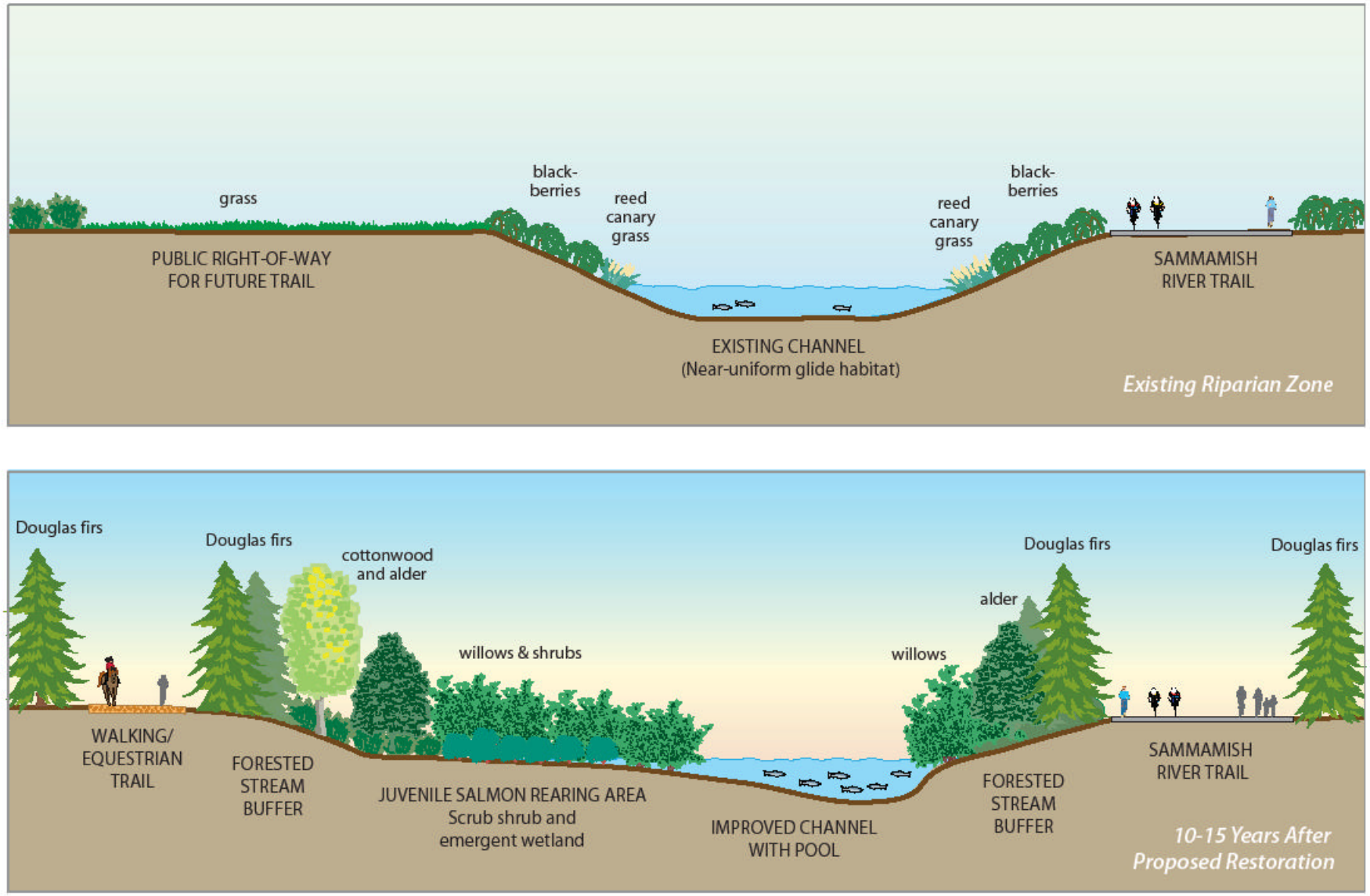

Figure 15

Cross-sections for Existing and Proposed Restored Riparian Zone

Sammamish River Corridor

0 5 10 20 30 Feet

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King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

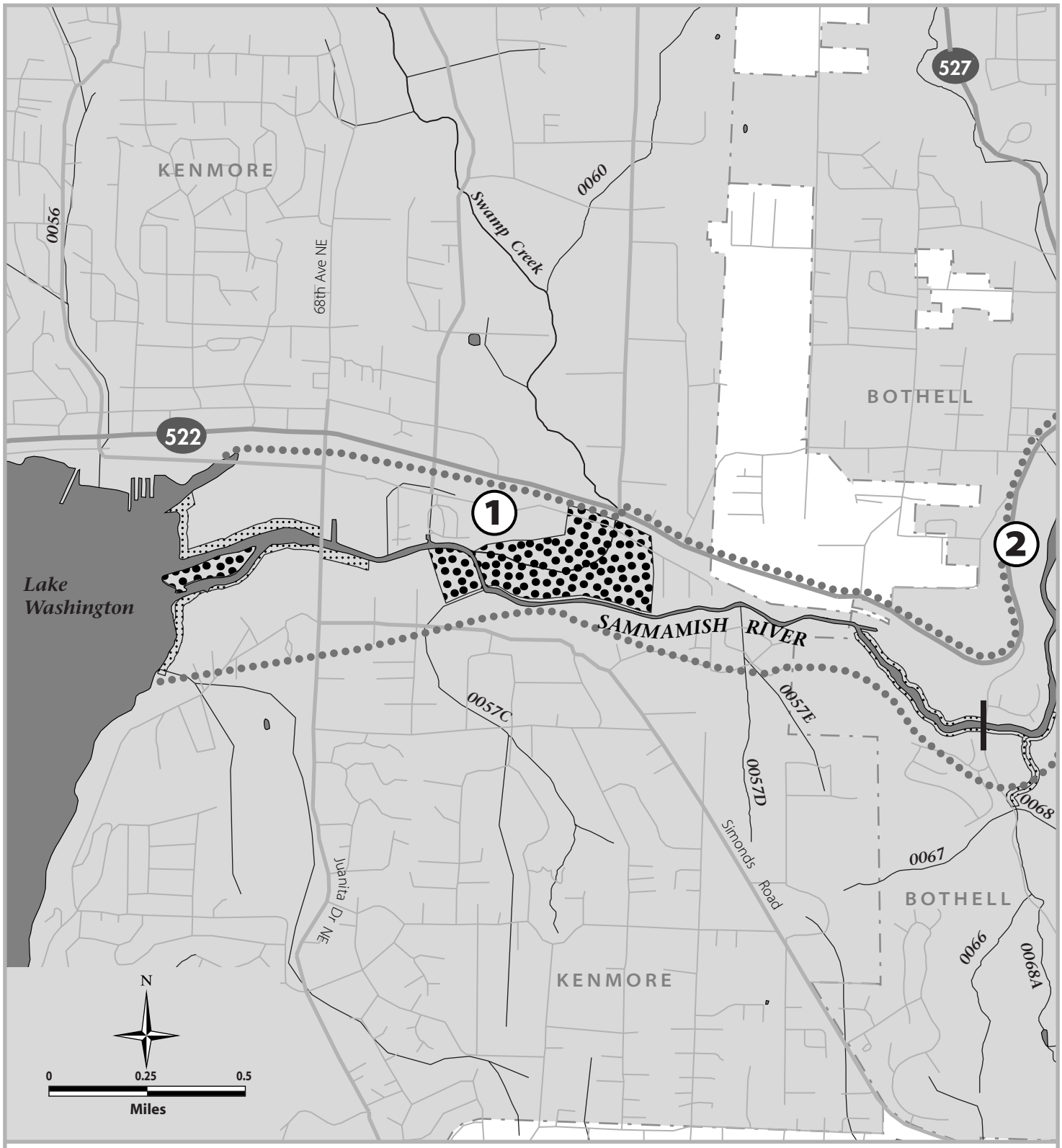

Figure 16

REACH 1 Proposed Restoration Areas

Sammamish River Corridor

King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

1 River Reach Number

River and Reach Boundary

Road

River/Stream

Planning Area Boundary

Incorporated Area

Riparian Restoration Area

Wetland Restoration Area

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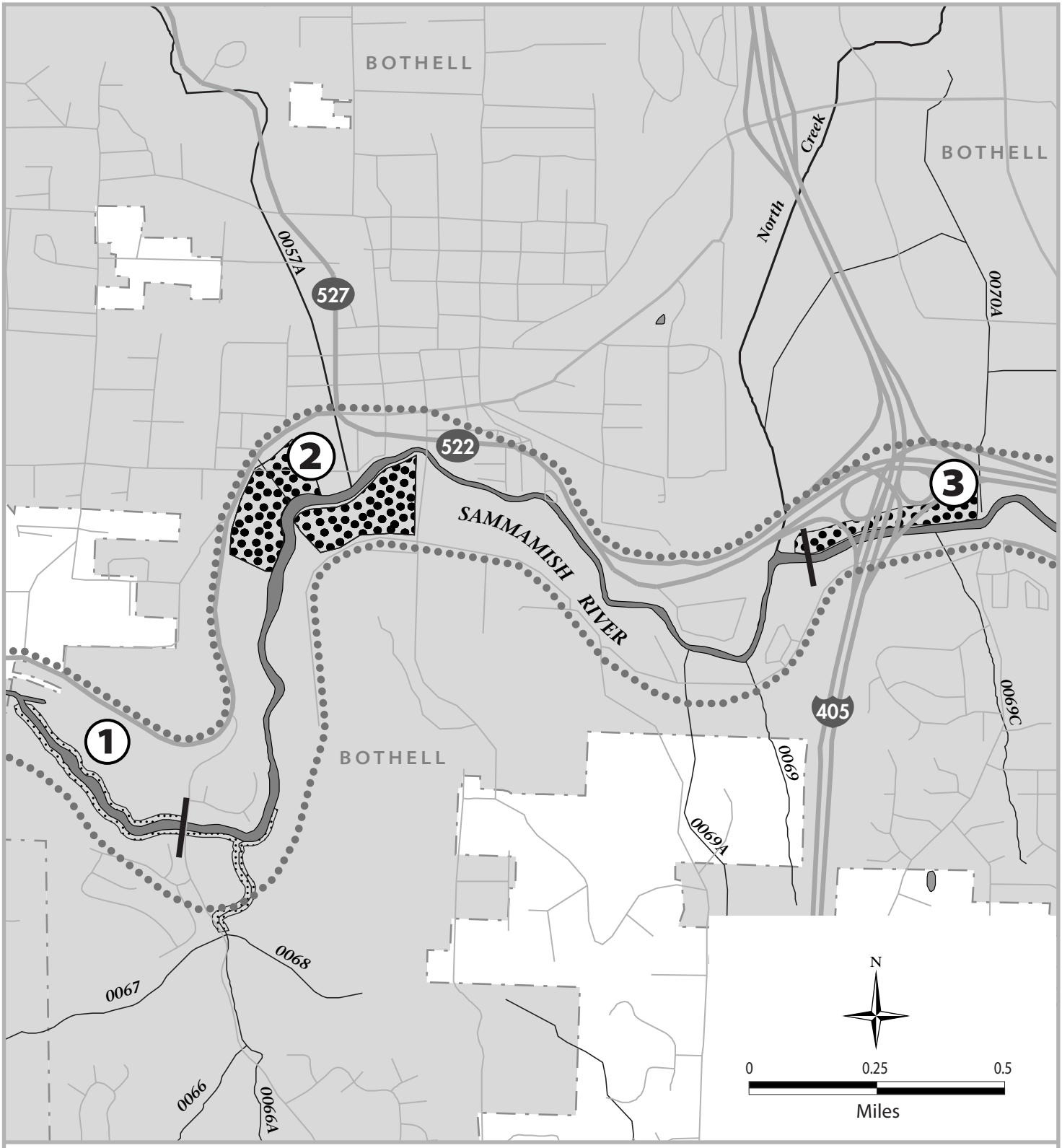

Figure 17

REACH 2 Proposed Restoration Areas

Sammamish River Corridor

King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

1 River Reach Number

River and Reach Boundary

Road

River/Stream

Planning Area Boundary

Incorporated Area

Riparian Restoration Area

Wetland Restoration Area

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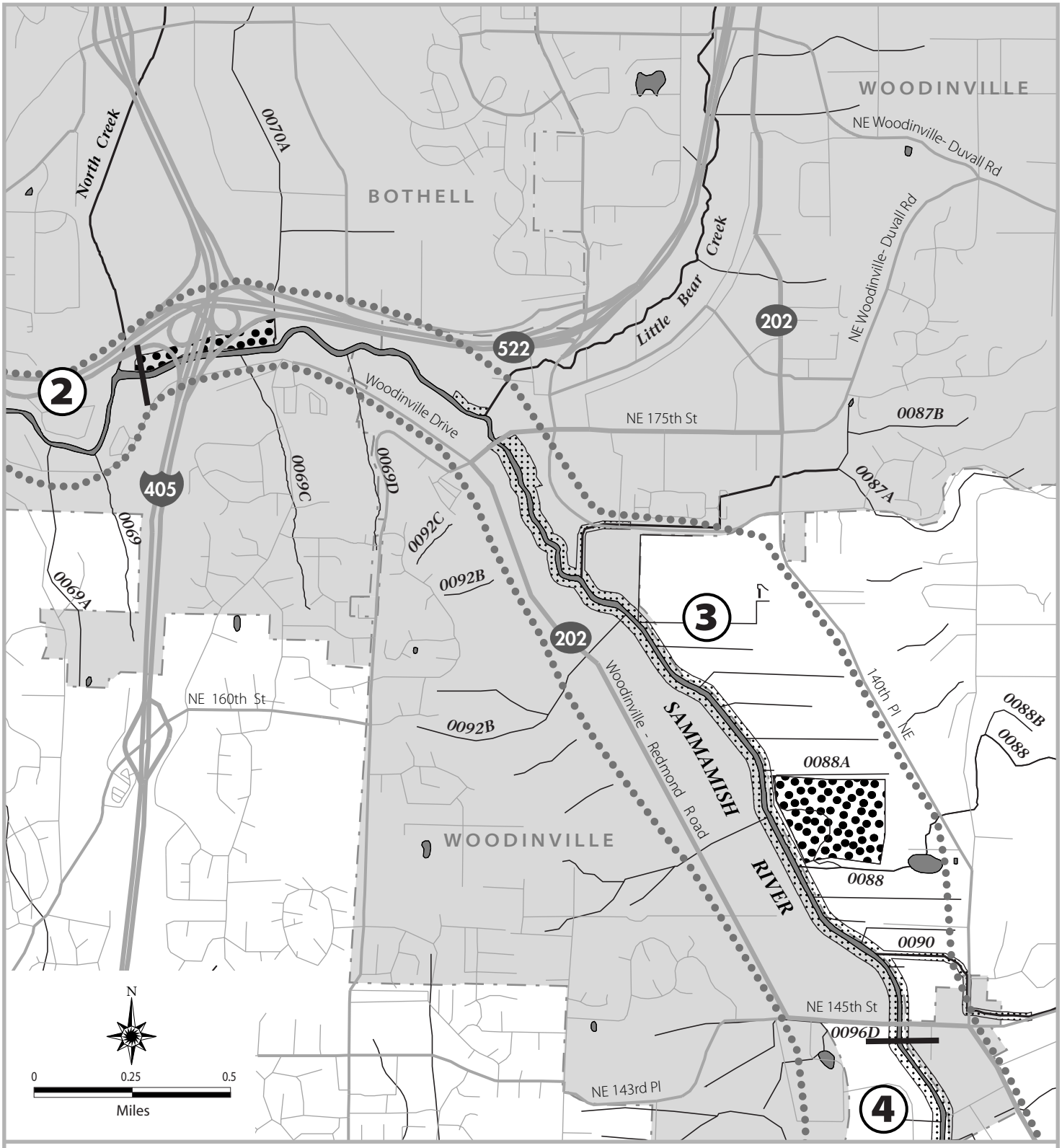

Figure 18

REACH 3 Proposed Restoration Areas

Sammamish River Corridor

King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

1 River Reach Number

River and Reach Boundary

Road

River/Stream

Planning Area Boundary

Incorporated Area

Riparian Restoration Area

Wetland Restoration Area

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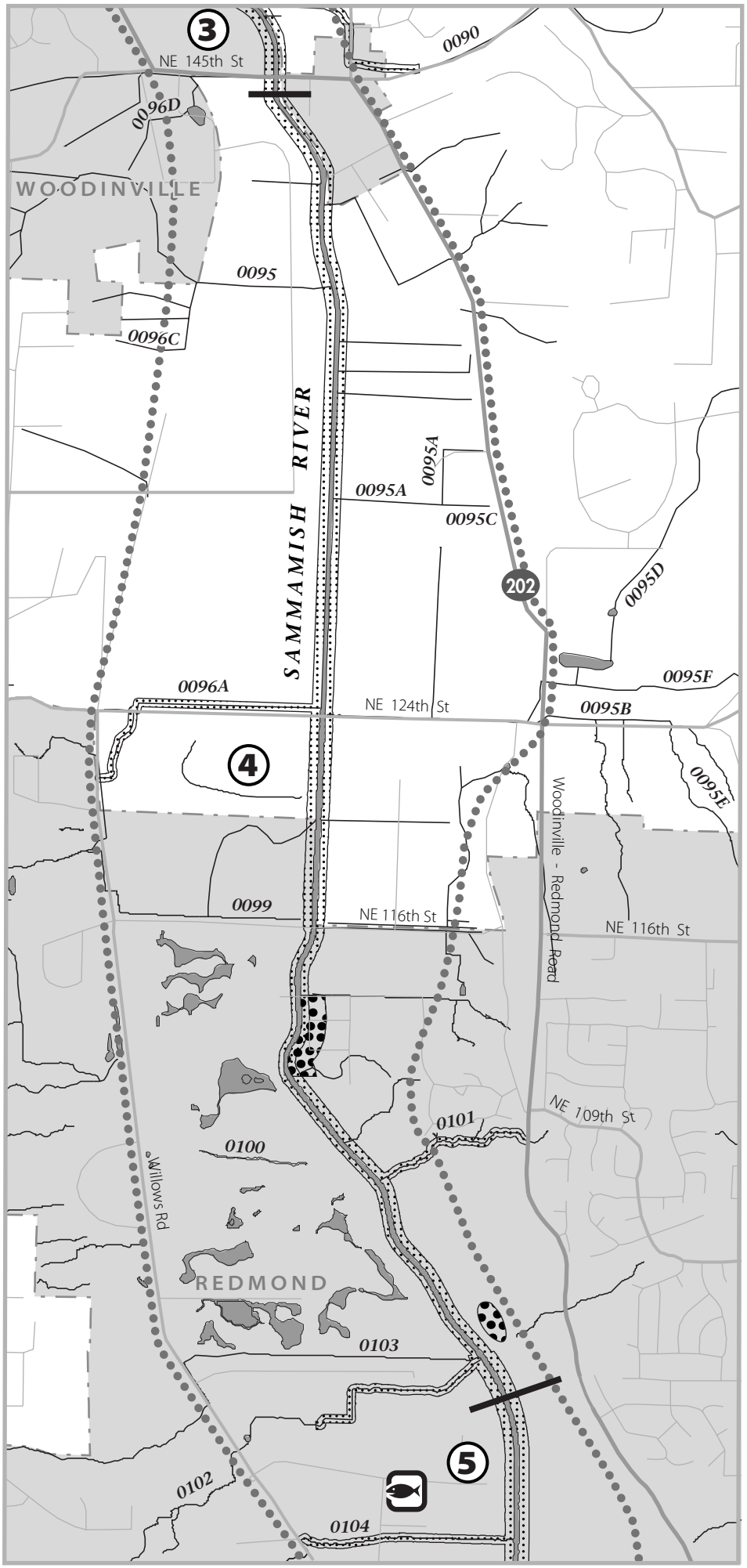

Figure 19

REACH 4 Proposed Restoration Areas

Sammamish River Corridor

- Road
- Stream
- Planning Area Boundary
- River and Reach Boundary
- River Reach Number
- Incorporated Area
- Wetland Restoration Area
- Riparian Restoration Area
- Removal of Fish Barrier

N

0 0.25 0.5

Miles

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King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

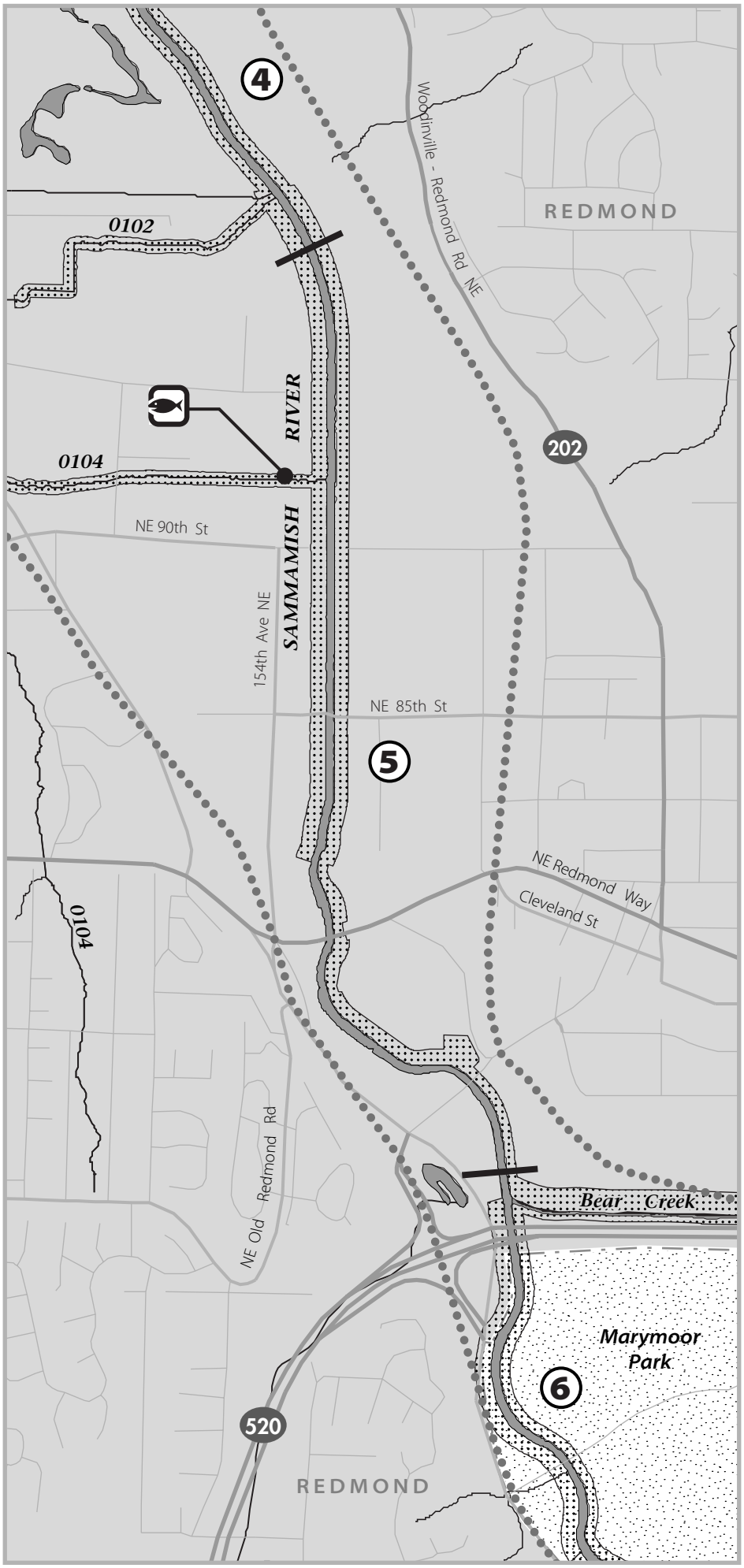

Figure 20

REACH 5 Proposed Restoration Areas

Sammamish River Corridor

- Road
- Stream
- Planning Area Boundary
- River and Reach Boundary
- 1 River Reach Number
- Incorporated Area
- Floodplain Restoration Area
- Wetland Restoration Area
- Riparian Restoration Area
- Removal of Fish Barrier

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Miles

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King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

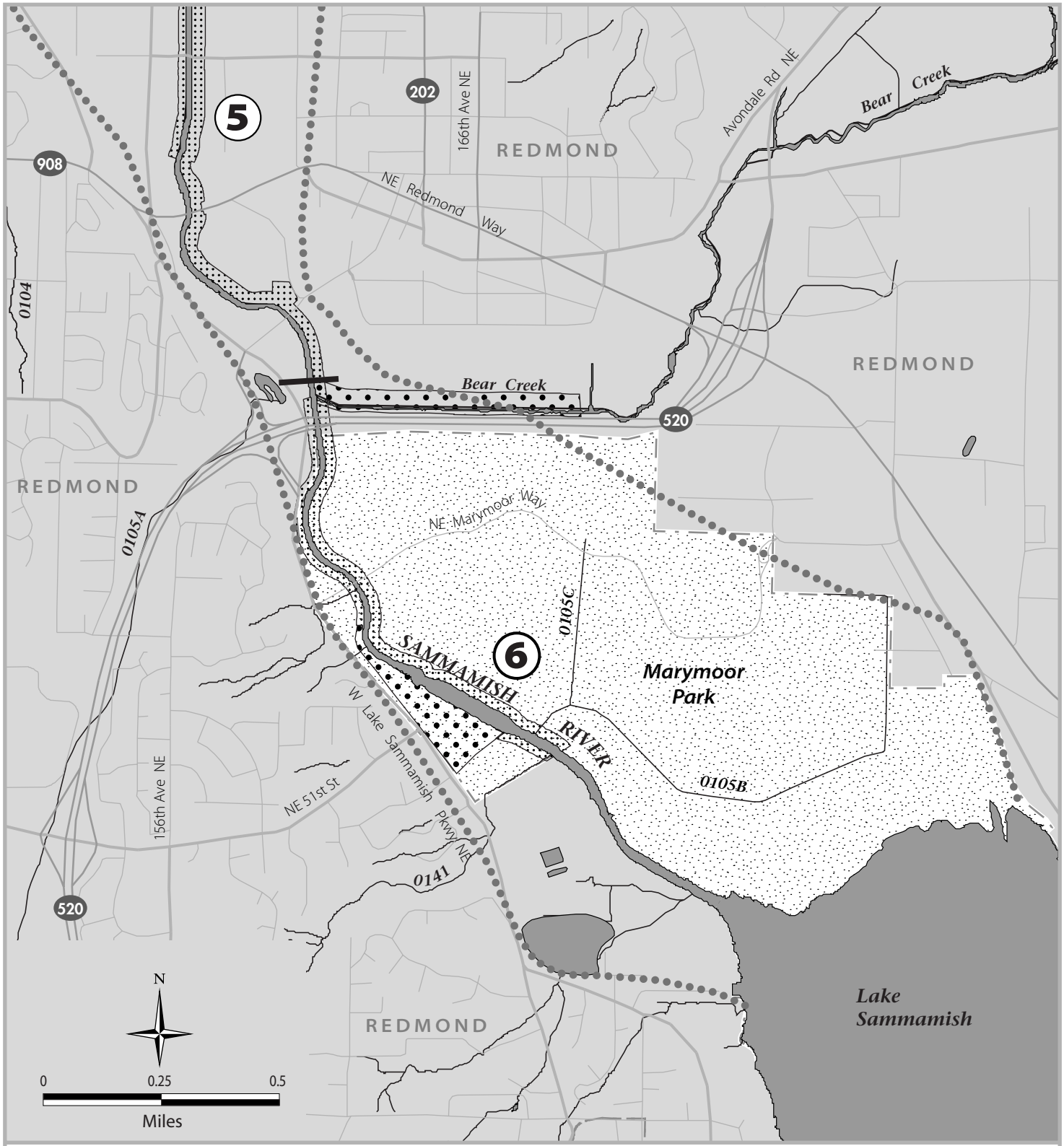

Figure 21

REACH 6 Proposed Restoration Areas

Sammamish River Corridor

King County
Department of Natural Resources and Parks
Water and Land Resources Division
GIS and Visual Communications & Web Unit

1 River Reach Number

River and Reach Boundary

Road

River/Stream

Planning Area Boundary

Incorporated Area

Riparian Restoration Area

Floodplain Restoration Area

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